than over the surounding area. Conditions seemed favorable for marked refraction, as a very shallow layer of surface air from the south underran a northerly wind all evening, which condition should have caused a marked temperature inversion.

The phenomenon was first observed by Mr. M. P. Hanson, the radio engineer, who came in and told me to go out and look at the sun, saying, "it is green." When I reached the outside it continued green. It had exactly the same appearance as an example of the green flash witnessed by the writer and others in April, 1926, between Norway and Spitzbergen, while on the Byrd Arctic Expedition, except in this case the flash lasted only for a fraction of a second.

Conditions were more favorable for its occurrence when first observed. Later the green appeared for shorter and less frequent intervals, and the orange and red flares increased in frequency.

Numerous times while on the barrier the writer looked for the green flash under quite similar conditions but failed to observe it. This fact would seem to indicate that a favorable condition of the air is necessary for its occurrence at a time when a very small part of the sun's disk is visible.

Among other members of the expedition who observed the phenomenon were Dr. Dana Coman, physician, Mr. Frank T. Davis, physicist; and Mr. Henry T. Harrison, meteorologist.

A FIELD ALBEDOMETER

By Prof. N. N. KALITIN

[L'Observatoire Géophysique Central, Leningrad, U. S. S. R., January 15, 1931]

Measurements of the albedo of the many varieties of earth surface are of interest in numerous lines of research, e. g., to meteorology, in obtaining true values of the gain and loss of radiant energy; to plant physiology, etc.

Systematic measurements of the albedo of various crops, taken at different stages of their development, have a special value for agronomical researches. For this last purpose it is necessary to have a portable apparatus allowing easy, rapid, and uninterrupted measurements.

The A. Ångström pyranometer is a very convenient apparatus for measurements of the albedo, being light and compact, but its installation proves most unhandy. The apparatus has to be fixed and leveled on a solid support (a tripod), at the end of a small rod which places it above the area to be investigated. This rod is so short that the pyranometer can be adjusted only over the edge of the area examined, e. g., field of crops. The readings of the apparatus may also be influenced by the support, and the transportation and installation of the tripod prove inconvenient and take much time. In order to eliminate these drawbacks a field albedometer, requiring neither support nor leveling, has been constructed by the author.

The design of this pyranometer is based on the adaptation of a Cardan's suspension which automatically brings the apparatus to a horizontal position. The construction of the pyranometer is as follows: In Figure 1 the receiving parts consist of 6 thin copper bands, 3 of which are coated with magnesium oxide,[1] and 3 with soot. On the back of the bands is attached a battery of 18 copper-constantan thermocouples.

The pyrheliometer is protected by a thin spherical glass cover. The casing of the pyranometer is supported from its upper part on two diametrically opposite pivots and fastened to a ring in such a manner as to allow it to rotate freely around both pivots. In turn this ring can rotate around two diametrically opposite pivots, disposed at right angles to the first two and fastened to the ends of a half ring soldered in the middle to a tube which may be put on a rod. In other words, the casing of the pyranometer is adjusted on a Cardan's suspension. The bottom of the casing being supplied with a lead weight, the receiving bands of the pyranometer are always disposed horizontally.

For the measurements of the albedo it is necessary to make the second series of readings with the receiving surfaces turned downward toward the surface to be investigated. It is sufficient, for this purpose, to turn the apparatus 180° around an imaginary axis passing through the rod. The casing of the pyranometer will be reversed, with the receiving surfaces directed downward and, having slipped 5 centimeters down along two guides (seen in the photograph), will assume a steadfast position, with receiving surfaces disposed horizontally. (See fig. 2.)

It is evident in both cases that the adjustment of the pyranometer is rapid and automatic. During observations the pyranometer is attached to a bamboo rod 3 meters long and connected by means of conductors with a galvanometer; the loop of the Zeiss galvanometer seems the most suitable in this case, being well adapted to field work. Two men, one operating the albedometer and the other taking the readings, can accomplish a very extensive piece of work during a day.

Figure 3 shows field work carried on by means of the albedometer. This apparatus also proves very convenient for measuring the albedo of water surfaces, when it is especially difficult to level the receiving surfaces.

[1] The method given by A. Ångström.

OBSERVING THE WEATHER AT MOUNT EVANS, GREENLAND

By LEONARD R. SCHNEIDER

For a person who had lived all his life in Illinois, in the heart of the Corn Belt, the weather of Greenland presented many unusual features. It will be a few of these features, arranged in a time sequence, which I wish to describe in the following.

As an introductory paragraph, it may be pointed out that two things account for the unusually large number of fair-weather days at Mount Evans. Undoubtedly the height and length of the great Sukkertoppen iceblink lying nearly 100 miles south of us was sufficient to interfere with and perhaps ward off frequent winds and storms that might otherwise come from that direction. But far more effective in the matter of bringing clear skies was the fact that the region was subject to the drying down-slope winds which prevail from off the ice cap. Being inland some 80 miles removed us from much of the wind that makes good use of the Davis Strait-Baffin Bay highway. But the camp's other dominant feature was the practically unlimited visibility, which a mountain-top position gave us.

Our first impression of Greenland weather lived up to the mental impression always created by the word "Greenland." On July 11, only two days after our arrival at Mount Evans, more than an inch of snow fell.

This made the work of transferring equipment rather tedious, but the snow cover disappeared within two days and maximum temperatures in the fifties were recorded and shortly after, on July 27, the maximum for the summer, 68°, was registered. This, incidentally, was the day scheduled for the arrival of Hassell, pilot of the *Greater Rockford*. From the weather notes of that day I find these words, "perfect weather, visibility good, sky clear, wind variable and light, and highest barometer for the month."

After our disappointment caused by Hassell's first smash-up near Rockford, nature appeared to be doing all she could to lighten our spirits. At any rate, on July 23 there was a rainbow in the northwest. I believe, however, that its splendor was even surpassed by the beautiful pillar of light cast by the sun during a 10:30 p. m. sunset on July 30. The purple reflection on all the near-by lakes reached the richness of the blue of our own Crater Lake. In addition to exceedingly beautiful sunsets which some evenings seemed only to lose their beauty when the morning sun came, the next thing of note was the first appearance of the aurora borealis from 7:30 to 8:30 on the evening of August 30.

Just as we had had a fall of snow to celebrate our arrival in camp, so it was on the day of departure of Doctor Hobbs and the summer expedition, that nature provided us with a covering of white. Two days later, on the 6th of September, the three remaining Mount Evansites officially declared summer to be at an end, for a film of ice had formed on the evaporation pans. Just as a further evidence of the fact that winter was coming, I found that on September 17 at 8 a. m. my shadow measured 30 feet; on the 22d it had increased to 36 feet and on October 5 to 57 feet. These shadows kept lengthening until on December 10 the shadows and the sun disappeared from sight. It was 30 days later when we recorded the next sunrise at 11:45 a. m.

During the winter there were several unique occurrences to which I should like to call your attention. This was the winter, you remember, when the Katigat was frozen and all of northern Europe was experiencing an exceptionally cold winter, and Chicago had its greatest snowfall. In direct contrast, the west coast of Greenland had one of its mildest winters; at least records show that the January maximum was 10° higher than any January of the past 30 years. During the same month at Mount Evans, what is remarkable is that one-fourth of the days of January had hourly temperature averages above freezing.

It was during these days that we compared radiograms; those from Denmark described the ice blockade, while those from Godthavn, in Greenland, announced that the snow had disappeared and that spring flowers might be expected any time.

Unfortunately, however, these warm days were not without some discomfort, for frequently when the temperature reached the fifties the wind reached the sixties. The wind reached its maximum velocity on January 24, when the southeast wind from off the ice cap reached exactly 100 miles an hour. At this registered velocity I shall allow you to cite your own figures for what the gusts might have been. At any rate, during this blow, after some moments of anxiety, we felt relieved when the anemometer slowed up, first to the nineties, and then to the eighties and seventies, for these blasts could only tug at our house, which was securely built and streamlined against the wind. During this period of hurricane winds our well-secured radio mast was flattened against the rocks, and that gave us something to talk about, but I doubt if it equalled the remarks occasioned by the wind's wholesale disposal of our year's supply of tin cans. To have been in that barrage might have been exceedingly dangerous.

Describing the winter would not be complete without a word or two concerning the snow, and as strange as it may seem, large snowflakes were extremely rare. Most frequently the snow was as tiny pieces, fragments of flakes. It was not uncommon, however, to see ice needles. While the snowflakes were small, the frost formations were often especially well formed. Some of the frost flakes measured one-half inch in length, and on these occasions thin wires became huge ropes, and other objects changed in size accordingly.

Once I was surprised to see some whopper snowballs on the lee side of Mount Evans. Before I could photograph them, and some of them measured as much as 8 inches in diameter, the wind increased in velocity and broke these curious formations probably as quickly as they were formed. Since this was on April 2, I considered it a sort of April-fool joke.

In contrast to our Cleveland weather, I find in my notes that on April 22, the rate of melting of the snow exceeded the rate of evaporation. Only upon this occasion was there the least little mud under foot. More often, however, and at times when the down-slope winds were stronger than usual, the wind would transport for miles considerable dust that it had picked up from the the dry-land areas along the fjord.

Most of what has already been said has dealt with the winter season, and perhaps it has been so because it has been difficult to determine the date for the arrival of spring, or perhaps better, summer. Snows were frequent all during the month of April and May, and the minimum temperatures were below freezing for the most part, yet on April 23 two flies made their appearance and ducks and geese came in from the south. Finally, however, on May 15, when along the lower slopes the buttercups were showing yellow flowers almost before they had sent up their leaves, we agreed that winter must be at an end. Ice, if this be any criterion, finally disappeared from the largest of our lakes on June 3.

The following is from my notes of June 12.

A foehn kept us busy to-day. Four balloons were sent up, one each at 9 a. m., 4 and 5 and 10:15 p. m. The last two disappeared into lenticular alto-stratus, and only the last one showed a slight backing. At 9:30 p. m., I counted 26 individual formations, but there were many others too small to count. Although during the evening the sky was practically covered with the lenticular alto-stratus, there seemed to be a level above which the formation occurred. Above that all were at more or less individual levels, with some being single and some multilayered. When the clouds came through the zenith I failed in an attempt to discover any difference in direction of movement within the cloud, that is, anything different from the general forward movement of the entire formation. When looking at the bottom of the clouds there appears to be a definite but raggy outline, and while from the side one sees a definite lens outline, some formations apparently grow down from a higher alto-stratus.

BRIEF DISCUSSION OF FOEHN CLOUDS

And now we fairly skim by an outstanding event, the midnight sun, and hurry along to the story of the schedule arrival of Parker Cramer in the Chicago Tribune plane, *Untin Bowler*. Most important in this was the fact that weather reports were coming to Mount Evans by radio three times daily from Cape Chidley, points along the west Greenland coast, Angmagssalik on the east coast, and from Iceland. The daily reports from New York were, however, much more complete, because they gave us a picture of the general weather conditions. While

Cramer was at Cape Chidley we attempted hourly communication with that station, and to the extent that fading entered in our efforts were successful in this. Cramer lost his plane at Cape Chidley, but on July 14, the day set for his arrival at Mount Evans, I find these notes, "This was the best day of the summer—clear sky, light surface winds, and moderate southwest wind aloft." A year earlier, when Hassell was expected, practically similar conditions prevailed.

In concluding this paper, I ought to relate our extreme temperatures. Winter's coldest was 41° below zero, while the maximum of the two summers was 70.1. One clear day, with a piece of black cloth, I coaxed the mercury up to 119°.

SUBSOIL MOISTURE AND CROPS FOR 1931

By HENRY C. SNYDER

[Weather Bureau Office, Denver, Colo.]

The dryness and extreme heat of 1930 were so unusual as to justify extra precautions in farming operations in 1931. In many instances wells and springs became dry that had never failed before, indicating that the subsoil water has been depleted to a dangerous point, when considering crop production for 1931. A short, dry period, such as is more or less common in the regions affected by the 1930 drought, would have more than the usual effect and cause an apparent unaccountable damage this year unless the depletion of stored moisture is considered.

It is practically certain that the drought area benefited little by hygroscopic moisture during the past winter months, and with a constant drain on capillary water for so long the outlook is very unfavorable. Water from the permanent water level may have helped some, but with our present knowledge of capillarity it seems that the subsoil could have benefited little from this source of moisture, as it is largely beyond reach. Under artificial conditions, capillarity has been known to extend 10 feet, but this required some 18 months, and the permanent water level is much deeper than this. With regard to soil moisture, the warmth of the past winter was also detrimental, in causing more than normal evaporation. Colder weather would have been beneficial in checking evaporation and thereby holding in check the capillary water that did reach near-surface depths. The results of a cold snap in spring illustrates the point. When this occurs there is a decidedly moist layer of earth a few inches below the surface, caused by checking the capillary water and condensing the water vapor in the soil. The moist layer is usually found from 10 to 18 inches below the surface, and the moisture so stored is readily available for plant use.

Evidence of the value of a saturated subsoil was gained in an experiment in which 2 pounds of water were added to a measured amount of surface soil. It was found that after 26 hours the soil so watered had gained 3 pounds of moisture, while the soil of twice the volume immediately below had lost 1¾ pounds. This would indicate that a moist subsoil is a material aid to rainfall under normal conditions, but little or no such aid can be expected this year. Because of the dryness of the soil it is far more probable that percolation will more than offset the forces of capillarity, thus making it imperative to have adequate and timely rainfall.

During a six weeks' drought in continental Europe in 1892, fruit trees failed to mature fruit, and many trees did not recover the following year. At the same time in California the normal dry season of from four to five months did not harm the orchards, as they produced a normal crop and without the aid of irrigation; surface tillage was used to conserve moisture. The trees in Europe were shallow rooted and depended on frequent rains, while those in California were deep rooted and could stand long periods of drought. Perennials in the dry-farming sections of the United States generally draw heavily on the subsoil moisture.

The amount of water evaporated by a growing crop is so great that it is practically certain that all the moisture is not usually secured by one season's rainfall. The amount necessary to mature a crop has been variously estimated at from two hundred to eight hundred times the amount of dry matter produced. Moreover, experiments have shown that plants that have taproots use little moisture from the surface soil and these require an abundant supply from the subsoil. A crop that uses surface soil moisture for plant evaporation required heavier and more frequent rains.

CORRELATION BETWEEN WEATHER AND PUNJAB WHEAT

Volume XXV, part 4 of the memoirs of the Indian Meteorological Department (Calcutta, 1929, p. 145–161, 2 pl.), is devoted to an article on Correlation Between Weather and Crops with Special Reference to Punjab Wheat by Rao Saheb Mukund V. Unakar.

The purpose of this study is to show the results of the research being done by the Indian Meteorological Department on the problem of wheat crop prediction in the Punjab.

In this section of India, wheat is sown in October and November, while the harvesting ends by the middle of April following. The authors make several predictions during this period, one at the end of each of the months of September to March. They have worked out correlation coefficients which take into account the meteorological elements of total Punjab rainfall, Lahore maximum temperatures, and Indus River levels, and the wheat elements of area sown, gross yield, and per acre yield. The Indus River level factor is included because nearly half the area of wheat sown in the Punjab is irrigated.

Tables show correlation coefficients for the various factors involved at different months of the growing season, and charts indicate graphically the degree of accuracy attained by crop predictions based on the meteorological factors. However, no figures other than correlation coefficients were shown which would indicate the percentage error of the crop predictions. These figures, together with a reduction of the amounts of production to bushels, seem essential to a better evaluation of the work being done by the Meteorological Department. To obtain this knowledge, and also to learn the degree of accuracy shown by the official estimates, the writer has taken the figures given in Table 8 and found the following results.

Over a period of 12 years the Meteorological Department's prediction in January showed an error of 12.8 per cent from the actual yield; its error on the March prediction amounted to 11.7 per cent. That of the official estimate showed an error of 6.9 per cent, but this prediction was made at the middle of April after the